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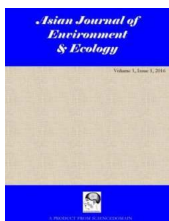
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Environmental Laws in Nigeria and Occurrence of Some Geohazards: A Review

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Authors' contributions

This work was carried out in collaboration between both authors. Author IEO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author CNC managed the analyses of the study. Both authors managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Nigeria as a country is blessed with an abundance of both human and natural resources. Exploitation of natural resources in Nigeria over the years with little or no regard for the environment has increased susceptibility of parts of the country to identified geohazards. A suite of environmental laws exist in Nigeria, all these aimed at protecting both the environment and its inhabitants. The aim of this paper is to review existing environmental laws in Nigeria, and occurrence of identified geohazards as a result of absence or non-implementation of these laws. Data for this study were obtained primarily from secondary sources. They are published government reports, journal articles, books, as well as other resources on the environment of Nigeria. Results show that Nigeria as a country has suitable existing and well-meaning environmental laws. The country also has many agencies charged with the responsibilities of implementing these environmental laws and policies. However, the non-implementation and non-existence of identified environmental laws and policies has increased both exposure and vulnerability of parts of the country to geohazards. The effects of these include; loss of means of livelihood, environmental degradation leading to Badlands in parts of the country, as well as death in extreme cases. It is recommended in this paper that adherence to existing environmental laws

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and policies as a panacea to mitigating identified geohazards is important. It is further recommended that amendment of already existing environmental laws to capture contemporary realities be made. This paper concluded by calling for more investment in the use of remote sensing and GIS tools such as LiDAR technology in the study of geohazards.

Keywords: Environmental laws and policies; geohazards; environmental degradation; Nigeria.

1. INTRODUCTION

It is often said that the environment can exist without humans but humans can barely exist without the environment. This has led governments all over the world to enact policies and laws aimed at protecting the environment and guaranteeing a sustainable environment for the unborn generations. Nigeria as a country is not left out in this case. A set of environmental laws and policies aimed at protecting the environment and its inhabitants exist in Nigeria. They include: the national policy on environment, the national forest policy, the national drought and desertification policy, national policy guidelines on solid waste management, national environmental (mining and processing of coal, ores and industrial minerals) regulations, and national environmental (soil erosion and flood control) regulations among others. These listed laws, regulations and policies are not exhaustive of all environmental statutes in Nigeria. The goal of these environmental policies is to ensure environmental protection and the conservation of natural resources for sustainable development [1]. Despite this, Nigeria, battles a variety of environmental problems which constitute geohazards at different scales. They include; oil spill in the Niger Delta, gully erosion which supports landslides in the southern part of the country, incidence of flood in all states bothering major rivers (e.g., Niger and Benue) as well desert encroachment in the northern region of the country. With a variety of natural minerals, Nigeria is endowed with sufficient resources which could translate into wealth for the country. Sadly however, damage to the environment is usually seen as an unavoidable consequence of maintaining national development [2]. This condition has led to near-total neglect of environmental laws in Nigeria at the pursuit of wealth and thus, many parts of the country bear the brunt of this neglect as evidenced in their susceptibility to a variety of geohazards.

By definition, geohazards are geological materials, features or processes that represent commercial and safety risks for development and

for the environment, [3]. They include earthquakes, tsunamis, landslides, gully erosion, flooding, fault rupture, turbidity currents, gas/fluid expulsion, over pressurised strata and adverse soil conditions. Geohazard triggering events may include seismicity, vulcanism, adverse weather conditions and human activities [3]. Nigeria is susceptible to a number of geohazards such as flooding, gully erosion and gully-induced landslides and oil spill. The aim of this paper is to review existing environmental laws in Nigeria and occurrence of identified geohazards as a result of absence or non-implementation of these laws. The objectives include; identifying existing environmental laws, identifying their degrees of implementation and ascertaining susceptibility of parts of the country to identified geohazards as a result of non-implementation or non-existence of environmental laws and policies. This is important for it is likely that exposure and vulnerability to identified geohazards would be reduced were there implementation of stipulated laws and regulations protecting the environment and its inhabitants.

2. ENVIRONMENTAL POLICIES AND REGULATIONS IN NIGERIA

Environmental policies are those guidelines, laws, and regulations governing the relationship between humans and the environment. They range from policies regarding air and water management to issues concerning biodiversity as well as food production. A suite of environmental policy exists, all these are aimed at addressing environmental issues and the conservation of natural resources for sustainable development. The Federal Government, through the Ministry of Environment in its effort to address environmental issues in Nigeria, has put in place a number of policy instruments/laws and regulations. Some of these policies include;

- i. **The national forest policy (2006);** this policy aims at achieving sustainable forest management that ensures sustainable increases in the economic, social and environmental benefits from forest

materials both for the present and future generations [4]. With a population growth rate of 2.9% per year, [5], pressure from developmental projects and cultivation practices in many parts of the country, natural forests are disappearing. In places, they are giving way for plantation agriculture while in other areas, former forested lands have been paved thereby reducing space for infiltration and increasing incidence of flooding, [6].

- ii. **National Policy Guidelines on Solid Waste Management;** aims at improving and safeguarding public health and welfare through efficient sanitary solid waste management methods that will be economical, sustainable and guarantee sound environmental health, [4]. Literature abounds on waste management in Nigeria [7,8,9,10]. Findings of these researches suggest that inefficient collection methods, insufficient coverage of the collection system and improper disposal characterise waste management in the country. Major constraints faced by the national policy guidelines on solid waste management include lack of institutional arrangement, insufficient financial resources, insufficient information on quantity and composition of waste, and inappropriate technology, [8]. Effects of these drawbacks include improper waste disposal, exposure and vulnerability to geohazards such as flooding. This is most visible where people dispose municipal waste in waterways and drainage channels. These activities block free flow and accumulation of surface runoff thereby increasing incidences of flashfloods in built-up environments. In the discussion of this policy, one asks, is there an Environmental Management Plan (EMP) for solid waste disposal? If there is none, then, enforcing this policy may not be very easy. An EMP for waste management takes into account volume of waste generated, means of evacuation, type of management to adopt, health implications and ways of avoiding such implications of waste management. A look around some Nigerian cities suggests that there are no EMPs for waste disposal. What is rather obtainable is 'waste relocation' in contrast to 'waste management'. A situation where municipal solid waste is transported from collection centres in the cities and deposited/dumped in borrow pits in the communities is not

healthy. Successive municipal authorities have set up agencies for waste management, many of these agencies failed because of lack of EMPs. Quantity of waste generated, type of waste (hospital or domestic, biodegradable or non-biodegradable), and type of management to be adopted are vital information that will aid this policy. Waste sorting is not a habit found among Nigerians. Biodegradable wastes are dumped on same site as non-biodegradable wastes and this poses a challenge to proper waste management. Use of open pits as waste dump sites is not environmentally friendly. They are breeding grounds for vectors, capable of contaminating ground water thereby undermining other environmental policies such as the National Environmental Sanitation Policy & National Environmental (Surface and Groundwater Quality Control) Regulations, S. I. No. 22 of 2011. Study has shown that absence of EMPs on waste disposal and management has led to the use of open pits as waste disposal centres in Nigeria [11].

- iii. **National Environmental (Mining and Processing of Coal, Ores and Industrial Minerals) Regulations, S. I. No. 31 of 2009;** seeks to minimize pollution from mining and processing of coal, ores and industrial minerals and encourage the application of up-to-date efficient cleaner production technologies, [4]. An aspect of this policy not fully appreciated is sand mining which leads to the excavation of borrow pits in various parts of the country. Study conducted by [11] on hazardous usage of abandoned borrow pit sites in parts of Imo State, Nigeria, identified a myriad of human activities occurring within these sites. Some of these activities include construction of residential apartments, recreational and waste disposal activities. These human activities expose users and dwellers around pit sites to a variety of hazards such as flooding, soil subsidence due to adjustment, accelerated gully erosion and possible occurrence of landslide, ground water pollution and water poisoning. They concluded that absence of EMPs for road construction and other engineering projects, as well as borrow pit excavation encourages hazardous usage of abandoned borrow pit sites in the study area. In some parts of the world, certain

criteria are set for borrow pit site selection and this is aimed at minimising adverse effects of borrow pits on both humans and the environment [12,13]. In Nigeria, borrow pits are seen as derived demands because they supply needed laterite for road construction and other civil engineering projects. On completion of sand mining however, what becomes of the borrow pit sites? Some models have been suggested to ensure optimal pit reclamation at the end of mining activities. For example, spatial decision-support system (SDSS) [14], and the analytical hierarchy process (AHP) [2]. These models were developed to mitigate possible impacts of open pit mining on the environment such as alteration of morphology, changes in hydrological pattern, loss of wild animal habitats, degradation of landscape value, reduction of property value, and loss of topsoil [14]. But since there is no EMP currently guiding borrow pit excavation in many states of Nigeria, these models cannot be adopted and implemented thereby exposing abandoned pit sites to avoidable geohazards.

- iv. **National Environmental (Soil Erosion and Flood Control) Regulations, S. I. No. 12 of 2011;** aimed at regulating all earth-disturbing activities, practices or developments for non-agricultural, commercial, industrial and residential purposes [4]. Erosion is one of the geomorphologic processes that affect an area [15], yet, it becomes hazardous when it interacts with human activities in the affected places. Human activities such as deforestation, uncontrolled grazing, [16,17,18,19] as well as engineering constructions have accelerated rates of erosion, thus, increasing consequences on affected communities as well as the environment. Gully erosion is a major environmental problem in many parts of the country, with special emphasis on south east Nigeria. A combination of both natural and anthropogenic factors trigger this geohazard, for example fragile geological formation, high intense tropical rainstorm that lasts up to eight months in the year, long history of settlement, deforestation, geotechnical and hydro-geochemical characteristics as well as poor land use practices [20,21,22]. Enforcement of this regulation will do little or nothing regarding natural causes of

gully erosion, on the other hand, the human related factors could be properly managed to reduce environmental vulnerability to gully erosion.

3. GEOHAZARDS IN NIGERIA

Nigeria is susceptible to three geohazards; gully erosion and gully-induced landslides, flooding and oil spill and other environmental hazards such as desert encroachment. This paper reviews exposure and vulnerability of parts of Nigeria to these identified geohazards.

- a) **Gully erosion and gully-induced landslides;** gully erosion is a major geohazard in Nigeria, with special emphasis on southern Nigeria. Some landslide events occur as a result of extreme gullying, they are thus referred to as gully-induced landslides. They are often manifest in the form of slumping as a result of toe undercutting from gully erosion. Gully erosion has attracted the attention of researchers in Nigeria for many years. [23] adopted Geographic Information Systems (GIS) as a tool to identify and study gully erosion hazards in Abia State, south-eastern Nigeria. They found that gully erosion sites were well dispersed around false bedded sandstone geological formation. Slope characteristics of gully sites were found to be greater than 15° which encourages erosion activities. [24] used a community-based low-technology approach to study gully erosion in south-eastern Nigeria. They established that many eroding gullies in the region were human-induced and preventable. Their results further revealed that many causes of gully erosion were traceable to poor land management practices and to a lack of innovation and awareness measures. They concluded that employment of community-based, low-technology land management practices and public awareness programs through workshops, could halt the development of many gullies in the region. Apart from natural factors such as geotechnical and hydro geochemical characteristics of soil, other factors have been implicated as causative factors of gully erosion. [25] identified human activities such as roadside excavation of borrow pits and absence of functional drainage systems, which causes runoff to wash off roads, as contributors to

accelerated erosion in south-eastern Nigeria. Many communities in southern Nigeria have suffered untold hardships as a result of severe gullying, loss of farmlands as shown in Plate 1, river silting, displacement of communities, threat to vegetation, property loss and effect on lives.

[26] documented some hazards associated with gully erosion in southern Nigeria. They stated that millions of people have been displaced and evacuated their homes following gully incidences, in Oko community of Anambra State, gully erosion has created a deep and wide crater, threatening to sweep away the homes of about 826 families. The authors added that 10 houses were lost in a single event of gully erosion in Auchi area of Edo State and over 450 buildings have been lost in Edo State of Nigeria as a result of severe gully erosion. They further reported that about 23 lives have been lost in the past few years in a single event of gullying activities in Ibori, Ugbalo, Ewu-Eguare, Idogalo and Oludide communities of Edo State, Nigeria.

- b) **Flooding;** flood can be defined as a hydrologic condition where the river discharge exceeds the storage capacity of the channel and the excess water overflows and inundates part of the valley bottom [27]. Flooding becomes a hazard when the valley flat of a river is utilized for settlements or economic pursuits. This becomes disastrous when floods and human settlements compete for the same location, [28,29]. The world over, flooding as an environmental challenge is widely studied because of the devastating effects it has on the environment [30,31,32,33, 34]. In Nigeria, it is said to affect and displace more people than any other disaster and also cause more damage to property [35]. The damage caused by the 2012 flooding in Nigeria was unprecedented. Heavy rains between July and October 2012 combined with rising water levels resulting from the runoff contributed to the flooding of human settlements located downstream of the Kainji, Shiroro, and Jebba dams on the Niger River; the Lagdo dam in Cameroun on the Benue River; the Kiri dam on the Gongola River; and several other irrigation dams. In some cases, the dams were damaged; in others, water had to be

released at full force to avert an overflow. 363 people were killed, 5,851 injured, 3,891,314 affected, and 3, 871, 53 displaced due to the resulting floods [36], effects of the 2012 flooding in Nigeria are shown in Fig. 1 and Plates 2 and 3. Apart from the 2012 flooding event which has already been highlighted, other major flood events in Nigeria are presented in Table 1. Extreme rainfall is a natural climatic factor capable of causing flooding, however, studies have also implicated human factors such as dumpsites within river channels and structural development within floodplains [35] as causes of flooding in Nigeria.

- c) **Oil spill;** the petroleum industry in Nigeria is the largest industry [37]. It generates over 90 percent of the nation's foreign exchange earnings and over 80 percent of government annual revenue [38]. Despite these, adverse effects of oil production in Nigeria are obvious in environmental, agricultural and health sectors. Published reports show that some activities associated with crude oil production with special emphasis on oil spill, can lead to environmental degradation, malnutrition in children and loss of livelihood [39,40]. Oil spill as an environmental hazard is almost exclusively restricted to the oil producing Niger Delta region of Nigeria. Causes of oil spillage include sabotage, seismic activities, pipeline rupture, as well as landslides among others. In Nigeria, majority of oil spill cases are associated with sabotage, but it is also likely that landslide events initiated by extreme gully erosion could lead to pipeline rupture. Published studies have not identified this possibility in the study of oil spills but given the problem of extreme gully erosion and incidence of gully-induced landslides in some parts of Nigeria, it becomes likely that a scenario like this may occur. Due to the environmental degradation often associated with oil spillage, scientists have studied their effects on almost all branches of life. [41] adopted the twin tools of GIS and Remote Sensing in an assessment of the physical impact of oil spillage in Jesse Town of Delta State. They found that oil spillage was increasing unabated in the study area. With this increase in the occurrence of oil spillage comes a commensurate increase in the degradation of agricultural lands thereby turning

hitherto productive areas into waste lands. [39] documented health hazards accruing from oil spillage. They found that oil spills could lead to a 60 percent reduction in household food security and were capable of reducing the ascorbic acid content of vegetables by as much as 36 percent and

the crude protein content of cassava by 40 percent. These they observed could result in a 24 percent increase in the prevalence of childhood malnutrition. The authors concluded that oil spills in the Niger delta region have acute and long-term effects on human health.



Plate 1. Severe gully site, Umueshi, Imo State, Nigeria

Table 1. Major flood hazards and disasters in Nigeria

State	Disaster	Associated hazards	Number of people affected	Year
Oyo	Ogunpa flood	500 Houses demolished, properties destroyed & bridges collapsed	50,000 affected	1948,1963,1978, 1980,1985,1987,1990 and 2011
Lagos	Flood	Buildings collapsed, markets submerged, properties destroyed.	Over 300,000 affected	Early 1970's Till Date
Kano	Flood and wind storm	Schools, Houses, Farmlands & Animals destroyed	300,000 displaced in 1988, 20,445 in 2001	1988, 2001
Edo	Flood & rainstorm	Rainstorm 560 Houses Destroyed	820 affected	March 2001
Akwa- Ibom		367 houses washed away	4000	March 2001
Adamawa	Flood & Rainstorm	Houses & Farmlands Destroyed	500	April 2001

Source: TS06J - Hydrography and the environment, 2011; [36]

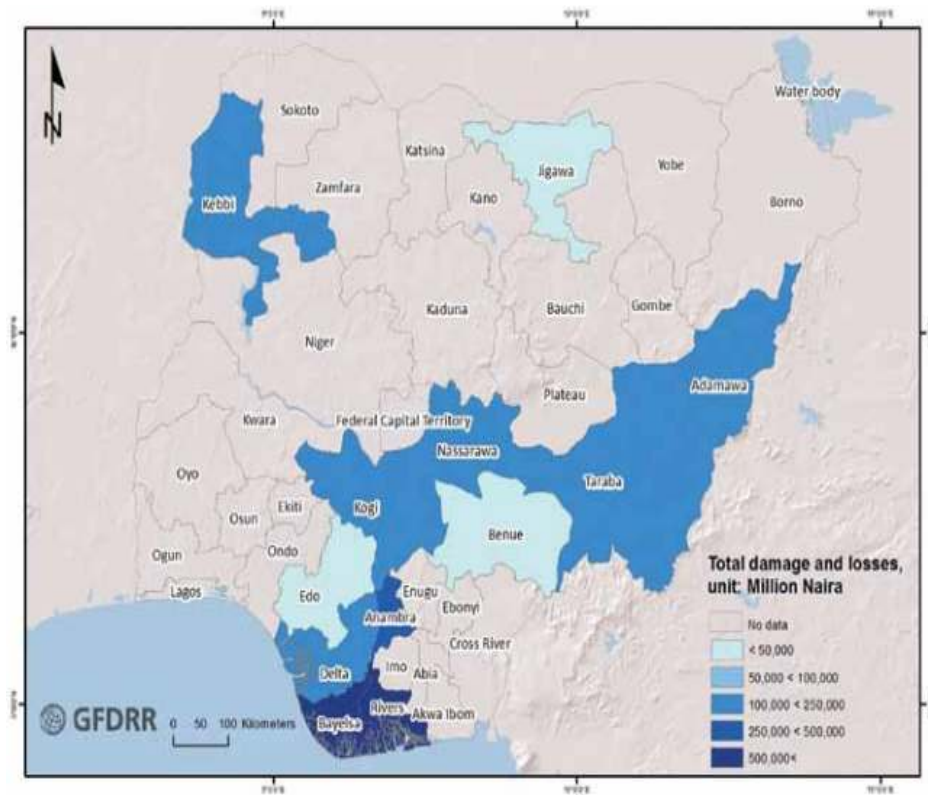


Fig. 1. Most affected states by the 2012 flooding in Nigeria
Source [45]



Plate 2. Submerged houses along Niger River in Lokoja
Source [46]



Plate 3. Severed major transportation route (Lokoja-Abuja) in Lokoja left travelers stranded

Source [46]

4. ENFORCEMENT OF ENVIRONMENTAL POLICIES AS A PANACEA TOWARDS PREVENTING AND MITIGATING GEOHAZARDS: NESREA

The dumping of toxic waste in Koko village of Delta State in 1987 reawakened the consciousness of the Nigerian Government to issues of environmental management. This event facilitated the establishment of the Federal Environmental Protection Agency (FEPA) in 1988. FEPA was charged with the overall responsibility for environmental management and protection. In 1999, FEPA and other related departments were merged to form the Federal Ministry of Environment. This new ministry did not have an appropriate enabling law on enforcement issues. This vacuum led to the establishment of The National Environmental Standards and Regulations Enforcement Agency (NESREA). NESREA, a parastatal of the Federal Ministry of Environment, was established in 2007 and is charged with the responsibility of protecting and developing the environment in Nigeria, as well as enforcing all environmental laws, regulations, standards, policies, guidelines and conventions on the environment to which Nigeria is a signatory. This agency has performed fairly well in few spheres, such as combating illegal importation and dumping of electrical/electronic waste (e-waste) in the

country. However, more needs to be done in the aspect of preventing and mitigating geohazards associated with non-implementation of already existing environmental laws as identified in this paper. Occurrence of identified geohazards in Nigeria would have been limited if NESREA as an agency was fully equipped with appropriate tools and manpower to discharge its duties as required by law. NESREA could strengthen the National Environmental (Soil Erosion and Flood Control) Regulations, S. I. No. 12 of 2011 by suggesting farming methods to be adopted in states based on their distinct characteristics related to gully erosion. NESREA could enforce a regulation that mandates developers to allocate a specified percentage of land to fallow, this would reduce the volume of storm water (produced from built up areas and paved surfaces) capable of causing floods and initiating gullies. Introduction and implementation of these regulations are all aimed at checking flooding, accelerated erosion and their concomitant hazards. If NESREA had the wherewithal to sanction airing contractors who engage in unsustainable civil engineering projects, that could prevent their environmental unfriendly activities. This could mitigate the onset of fresh gullies while efforts are made to manage already existing gullies. As observed by [35], some causes of flooding in Nigeria include dumpsites within river channels and structural development

within floodplains. Again, in the implementation of the National Policy Guidelines on Solid Waste Management, NESREA could collaborate with state and local governments to ensure that management of one problem does not lead to the creation of another. Cases where municipal waste is either relocated from cities to borrow pits in the communities or simply dumped in waterways create more problems for Nigerians than they can solve.

5. RECOMMENDATIONS

Having reviewed on one hand existing environmental laws and regulations in Nigeria as well as their level of implementation, and exposure and vulnerability of parts of the country to identified geohazards on another hand, this paper makes the following recommendations.

- a) Assembling an expert Geohazard Assessment Team (GAT) in vulnerable states; this team will normally comprise experts from environmental management, geomorphology, geology, geophysics and geotechnics. This team would conduct research on the exposure and vulnerability of regions to geohazards such as flooding, extreme gullying and gully-induced landslides. The method developed by the GAT provides a framework for estimating; the frequency at which different geohazard events could be expected to cause loss to the environment; and – the level of financial loss associated with the different geohazard events [42]. Further, magnitude and frequency of such geohazards are also documented by the GAT, this will give policy makers an idea of the nature of the problem the environment is exposed to. The use of Quantitative Risk Assessment (QRA) method is often adopted in assessment of geohazards such as landslides. Quantitative risk assessment involves estimating the probability of landslide events of different magnitude and their consequences [43,44]. Such approaches could be adopted in assessing and communicating vulnerabilities of regions to gully-induced landslides. This will be a major way forward in preventing and controlling gully-induced landslides in parts of Nigeria. When this is implemented, it would almost eliminate the probability of oil spill occurrence in Nigeria as a result of landslide event.
- b) Strengthening existing environmental laws; environmental laws and regulations such as the National Environmental (Mining and Processing of Coal, Ores and Industrial Minerals) Regulations, S. I. No. 31 of 2009 and the National Policy Guidelines on Solid Waste Management could be strengthened to include implementation of Environmental Management Plans (EMPs). With regards to the guideline on waste disposal and management, NESREA could collaborate with state ministries of environment to ensure workable EMPs are in place for waste management. Such a guideline for waste management would include volume of waste generated, means of evacuation, type of management to adopt, health implications and ways of avoiding such implications of improper waste management. Implementation of this recommendation would reduce incidences of use of abandoned borrow pit sites as dumpsites as well as cases of flooding occasioned by refuse dumps on waterways. Secondly, in collaboration with the states, NESREA could include implementation of EMPs in the Environmental Impact Assessment Audit required for issuing licenses to natural resources extraction companies. This addition should consider possible ways of sustainable reclamation of abandoned mine sites. This is particularly important as regards sand mining and excavation of borrow pits. If these EMPs are added to already existing statutes as listed and implemented, environmental exposure and vulnerability to geohazards would be prevented and reduced.
- c) Finally, strict penalties should be handed down to oil companies who fail to clean oil spills from their facilities within a specified duration. NESREA as a body in collaboration with other agencies such as the National Oil Spill Detection and Response Agency (NOSDRA) could sponsor legislations that give them legal backing to implement such regulations. Implementation of these recommendations should rest with NESREA since it is the body established by law to implement all environmental regulations and statutes of the Federal Republic of Nigeria. Incidences of geohazards emanating from non-implementation of environmental laws would be drastically reduced if the recommendations of this paper are

considered by the relevant authorities of the government.

6. CONCLUSION

This paper set out to review already existing environmental laws in Nigeria as well as susceptibility of parts of the country to identified geohazards as a result of non-implementation of these laws. A suite of environmental laws exist, parastatals within the ministry of environment also exist. However, parts of the country are exposed and vulnerable to identified geohazards such as gully erosion and gully-induced landslides, flooding and oil spills. Academics and researchers over the years have proffered solutions to these three identified problems, however, these hazards still constitute challenges to the inhabitants of the environment in Nigeria. Extreme gully erosion has attained a disaster level in southern Nigeria with some gullies growing to depths of 12m and lengths of more than 1.5 km long [26]. The use of airborne LiDAR in gully erosion studies has been identified as one of the most promising data sources for studying gully systems because of its fine resolution and high accuracy [47]. Airborne LiDAR has the ability to accurately represent gully cross-sectional form [48,49], to map the location of gully heads [50], and to characterize gully networks [51]. Adoption of this technology as well as other remote sensing and GIS tools would lead to better management of gully erosion and gully-induced landslides. Use of modern technology in monitoring oil spillage in the oil producing environments of Nigeria will identify oil spillage as quickly as possible. This will reduce hazards associated with prolonged abandonment of spills on the environment which exposes the environment and its inhabitants to risks. Finally, implementation of the environmental management plans already discussed in this paper would reduce exposure and vulnerability of many regions of Nigeria to human causes of flooding.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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